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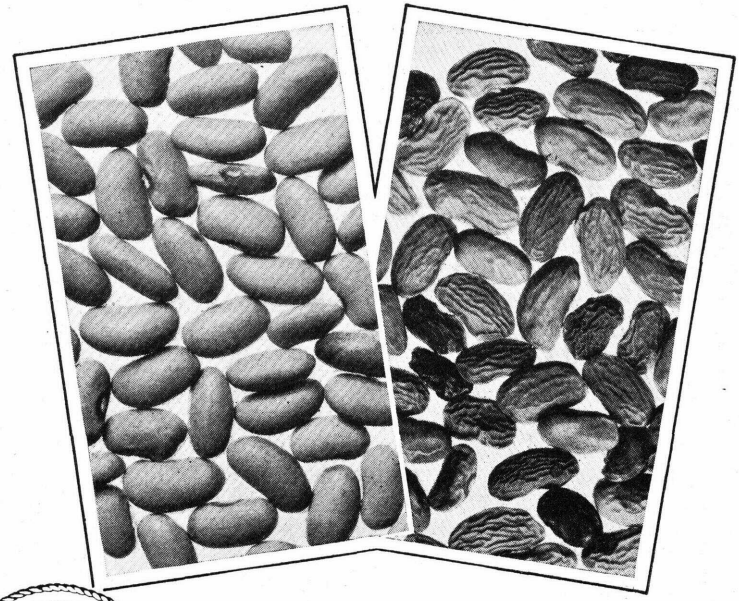
# BEAN DISEASES and THEIR CONTROL



BEANS are subject to a number of diseases that cause injury and loss. The purpose of this bulletin is to describe these diseases briefly, so that they can be identified by the grower, and to give recommendations for preventing and checking them.

Anthracnose is a seed-borne disease. To control it, use seed grown in regions where it does not occur. Such seed is grown in Colorado and the States west. Practice a crop rotation of three or four years when possible.

Bacterial blight is also seed borne, and the control measures are the same as for anthracnose. Seed grown in the western part of the United States carries less infection than eastern-grown seed.

Mosaic is likewise seed borne. No satisfactory means of control are known. It is advisable to plant mosaic-free seed when it is obtainable. Where mosaic limits successful growing, use resistant varieties.

No control for rust is known. Planting immune or highly resistant varieties is recommended.

Powdery mildew can be controlled by one or two dustings with powdered sulphur, the first to be applied as soon as there is any evidence of disease, and the second, if necessary, one to two weeks later.

No satisfactory control for root rots is known. Rotation of three or four years with such crops as corn, oats, rye, and alfalfa, and maintaining the highest degree of tilth of the soil, help to reduce the loss. Breeding resistant varieties is about the only permanent solution of the problem.

To control root knot, caused by parasitic eelworms, plant immune crops and practice crop rotation.

No control for yeast spot of Lima beans is known.

The pod blight and downy mildew of Lima beans are seed borne. The causal organisms also live over winter on dead plant parts left in the field. When possible burn the old vines and pods. These diseases do not occur in the West, where most of the Lima-bean seed is grown. It is advisable to procure western-grown seed rather than to save seed from a previous crop. A 4-4-50 Bordeaux spray might help to check the diseases, although its use is not generally recommended.

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# BEAN DISEASES AND THEIR CONTROL

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## THE BEAN INDUSTRY AND LOSSES FROM DISEASE

BEANS are important in the diet of a large portion of the world's population. They are grown in practically every part of the United States. Most farmers and many urban home gardeners grow them for home use. The commercial bean industry in the United States has grown to large proportions. Those engaged in it may be divided roughly into four groups: (1) The market gardeners, who grow beans for consumption as a green vegetable; (2) the growers of dry shelled beans; (3) the seed growers; and (4) the canners.

The market gardening of green beans is carried on by a large number of farmers along the Atlantic seaboard from the South into the North, along the Pacific coast, and to a lesser extent throughout the Central States. The culture is now so widely distributed that green beans are available most of the year in many parts of the country. Dry shelled beans are not quite so generally grown, but occupy far greater acreage and are produced in much greater volume. The bulk of the dry shelled beans is grown in a few Northern and Western States. The seed-growing industry is restricted mainly to varieties of garden and Lima beans and is centered in a few Northern and Western States. It is largely in the hands of a comparatively small number of firms, although a considerable number of farmers grow seed for the commercial concerns. Commercial canning of green beans has increased materially in recent years and is carried on in many States. A large number of farmers grow beans for the canners. Since 1922 the canning business has sprung up in new territory, but the largest volume of production is in New York, Maryland, and Wisconsin.

Regardless of the type of bean production followed or of where the crop is grown, certain diseases are prevalent. Bean diseases are not restricted to varieties grown by any one or more groups, but are limited only by climatic conditions. They cause serious damage and loss in various ways: By killing seedlings; by injuring or killing the growing plants; or by spotting and decaying the pods and seeds and thus lowering the yield and rendering much of the product unmarketable. Under conditions especially favorable for the development of disease the losses may be very heavy. The disease problem is therefore a serious hazard.

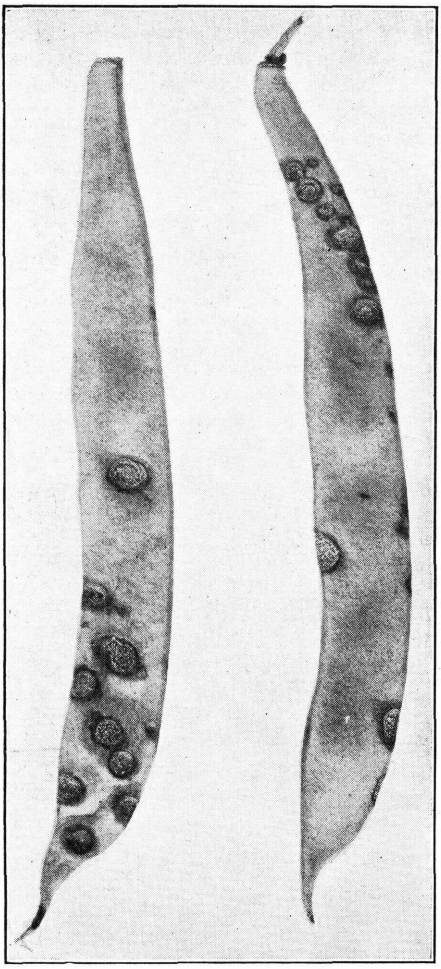

FIGURE 1.—Bean anthracnose on the pod. The roundish, sunken cankers contain myriads of spores, which may be carried to other pods or to the leaves and start new lesions

This bulletin gives brief descriptions of the various diseases, information on their causes, and recommendations for their prevention and control. Unfortunately, in some cases no control measures are known.

## DISEASES OF GARDEN AND FIELD BEANS

### ANTHRACNOSE

#### DESCRIPTION

Bean anthracnose is of major importance to growers in the Eastern and Southern States, since in certain years when conditions are favorable the disease may be so widespread that it renders entire fields practically worthless. It may not only kill the seedlings, but it often infects older plants badly, and spots the pods so severely (fig. 1) that they are unfit for consumption. Anthracnose may occur on any part of the plant above ground during almost any stage of its life.

Infected seed (fig. 2) is characterized by dark sunken lesions of different sizes which may extend just through the seed coat and penetrate the cotyledons. Spores form in these lesions, which are sources of infection of the stem and young leaves, which in turn may become sources of infection for the older leaves and pods. The oval cankers on the stem are sunken and

range from brown to nearly black in color, with a somewhat purplish to brick-red border, the long axis of the canker extending up and down the stem. The fungus may so weaken the stem that it is easily broken in cultivating or by a strong wind.

Anthracnose generally follows the veins on the underside of the leaves, causing them to become dark purplish to dark red. These streaks may be found on most of the veins of a leaf or on only a few in isolated regions. In severe attacks dead angular spots show on the upper surface of the leaves, giving them a ragged appearance.

It is on the pods, however, that the disease is most conspicuous. It begins as minute, reddish-brown, elongated spots which are often oblique to the long axis of the pod. These spots, often quite numerous, gradually become more or less circular and sunken at the center, surrounded by a rusty to brown-colored border. The spots may be one-fourth of an inch or more in diameter when mature. During moist weather numerous spores are produced within the cankers, and give them a somewhat pinkish color. When the pods are picked it is sometimes not easy to detect very young lesions, but under suitable conditions they may develop into conspicuous cankers in a few days. These cankers frequently extend entirely through the walls of the pod and often into the seed, where the disease organism may live buried beneath the seed coat for many months. The new crop becomes diseased principally through infected seed.

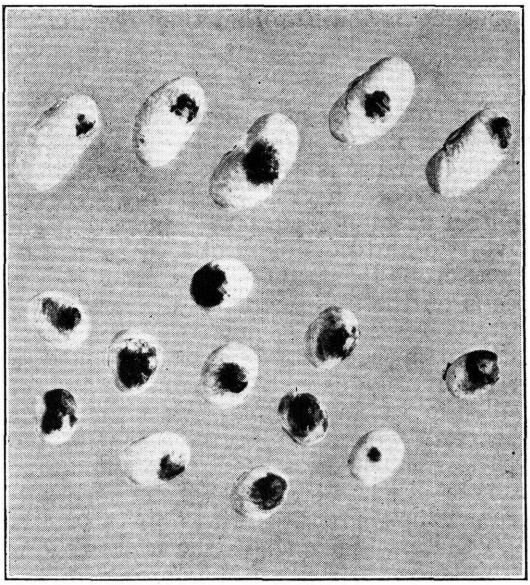

FIGURE 2.—Bean anthracnose on the seed. The seed is infected through the cankers on the pods. Infected seed serves as a means of infecting the new crop and should never be planted

## CAUSE

Anthracnose is caused by a fungous parasite, *Colletotrichum lindemuthianum* (Sacc. and Magn.) Briosi and Cav., which attacks beans and a few other related plants. The pinkish centers of the cankers are composed of myriads of spores, or seedlike bodies, which are disseminated by various means to other plants and plant parts, where a new infection is established. These spores are also found to a less extent in the lesions on the leaves, petioles, and stems.

Wind and rain are probably the two principal agencies in disseminating the spores, which, however, may also be carried on the bodies of insects, on the hands of laborers picking beans, on farming implements, and by various other mechanical means. The spores are embedded in a sticky substance which readily adheres to whatever it touches. For this reason it is not advisable to enter bean fields to pick or cultivate the beans when the foliage is wet.

Anthracnose may be carried over from one season to the next on old vines in the field and by means of infected seed. It is not known just how long the spores will survive under field conditions, but experiments indicate that they remain viable at least two years.

### CONTROL

The control of anthracnose by spraying and dusting with fungicides has not been especially effective, and until more information about their use is available they are not recommended.

Crop rotation is a good practice even if not necessary for the control of plant diseases. Since bean anthracnose is known to survive two and possibly three years in the field on the débris of previous crops it is advisable to practice a rotation that will not bring beans on the same ground oftener than once every third or fourth year.

Bean anthracnose is a seed-borne disease. During the growing season in regions where the disease occurs and cankers develop on the pod, the fungus often grows entirely through the pod and enters the seed, where it may remain alive for months and possibly for years. When such seed is planted and germination begins, the fungus likewise starts to grow, forming lesions on the cotyledons, from which later infections on the stem, petioles, leaves, and pods may arise. Inasmuch as the seed is the most effective means of disseminating the disease, it is highly important that only disease-free seed should be planted. Such seed can be obtained with certainty only from regions where anthracnose does not occur.

Beans are grown in most parts of the United States, and seed beans of the garden varieties are grown in a number of isolated regions in the East, in the Intermountain States, and along the Pacific coast. Anthracnose is very sensitive to changes in temperature and humidity and develops most abundantly in cool, wet weather, and largely disappears under hot, dry conditions. This fact explains why the disease is present in the East to some extent each year, while in the arid West it is seldom if ever found. Beans grown in Colorado and all of the other States farther west are free from the disease. Wherever possible seed from such regions should be used where anthracnose-free seed is desired.

Anthracnose occurs on practically all varieties of garden beans and on most of the dry shelled field sorts. In a few varieties of field beans, such as the Wells Red Kidney, White Imperial, and Perry Marrow, strains that are resistant to anthracnose have been developed. Those varieties are grown to only a limited extent in a few localities in the United States. Most of the more popular field varieties are quite susceptible to anthracnose.

## BACTERIAL BLIGHT

### DESCRIPTION

While bacterial blight of beans is caused by two distinct organisms, the symptoms produced by the two are so similar that one description will answer. Probably the most striking evidence of these dis-

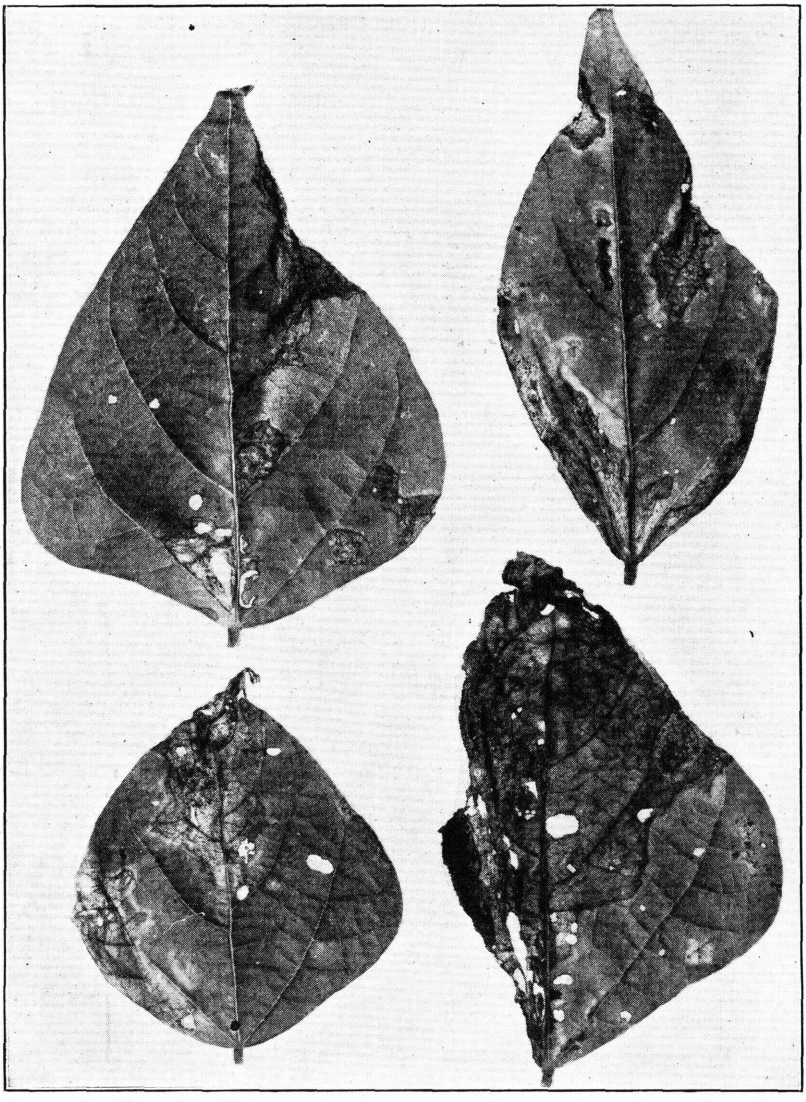

FIGURE 3.—Bacterial blight on the leaves. Note the dead portions. Sometimes the injury is so extensive that growth of the plant is almost entirely stopped

eases is noted on the leaves where the lesions first appear on the underside as small water-soaked spots. As these develop, a slight incrustation of dried bacterial ooze can be seen in their centers, surrounded by a yellowish zone resembling a halo. Different lesions

may gradually merge, producing a brown, dead area (fig. 3), and in time causing defoliation of the plant.

The bacteria may cause one or another type of lesion on the stem. On the young seedling the diseased area starts as a small water-soaked spot which gradually enlarges and later takes on a reddish coloration. On the older stems the lesions appear as reddish dashes extending lengthwise along the stem.

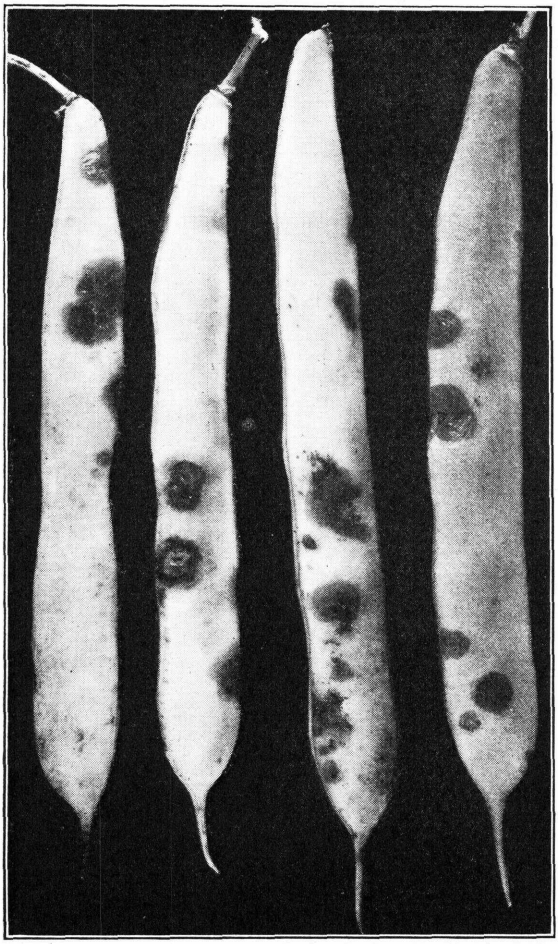

FIGURE 4.—Bacterial blight on the pods, showing reddish, water-soaked, irregularly shaped, slightly sunken spots. The seed may be invaded and serve as a source of infection for the new crop. Blighted seed should never be planted

When the plants are in the earliest stage of pod formation a characteristic lesion known as stem girdle or joint rot often appears. The lesions start at the nodes of the plant as small water-soaked areas and, as they enlarge, encircle the stem. Later these diseased regions become amber colored. The girdling is usually completed when the pods are half mature, and the affected stem is further weakened by the increasing weight of the top, so that it often breaks at the diseased node.

The disease causes much damage to the pods. (Fig. 4.) The bacterial spots start as minute water-soaked areas which become larger, and a discoloration with a distinct zoning follows this growth. Later the spots become dry and sunken and take on a brick-red color. Often a dried mass of bacterial slime can be seen covering the lesions.

The bacteria may also infect the upper hinge or suture of the pod, causing discoloration of this region and water-soaking of the surrounding tissue. Through this region the organism may attack the seeds, producing several types of lesion. When infection occurs while the pods are young, the seeds may rot completely, or become so severely infected that only the shriveled seed coats remain, or the bacteria may enter and discolor the hilum (the point of attach-

ment of the seed to the pod). These lesions are difficult to detect in the case of slight infection, but with severe infection they cover a considerable area and produce a varnishlike appearance. On seed of light-colored varieties the symptoms are conspicuously manifested, but on dark-colored seeds they are easily overlooked.

When badly diseased seeds are planted, the seedlings may not push through the ground at all, or may be stunted and dwarfed. Some seedlings may grow to considerable size, but close examination usually reveals a lesion at the node where the cotyledons were attacked. This develops later into the stem girdle and usually results in the plant's breaking over at the time of pod formation.

### CAUSE

The two organisms (*Bacterium phaseoli* E. F. Smith and *Bact. medicaginis* var. *phaseolicola* (Burkh.) Link and Hull) that cause bacterial blight produce symptoms that are difficult to differentiate. At times these causal organisms may be systemic; that is, they may traverse the plant through the water-carrying vessels or ducts without producing any external lesions. The seeds may become infected in this manner. When such seed, which apparently is healthy, is planted, the bacteria enter the young seedlings and produce disease in the plants.

Ordinarily the disease does not cause severe damage in the field until weather conditions favorable for the spread and development of the organisms prevail. The disease is favored by high temperatures in conjunction with heavy dews and rains. The bacteria may enter the stomata (breathing pores) of the leaves, stems, and pods, such penetration being favored by periods of rain or damp weather.

Blight may occasionally occur in regions of relatively low humidity. Under such conditions the organism does not react as it does in sections of high humidity. The most important symptom appearing under such conditions is stem girdle. Here, the organism is carried over in the seed and gradually infects the interior of the plant, working in the water ducts. Outside influences have little effect on the organisms, since there is sufficient moisture within the plant to allow them to develop. When the bacteria have increased to sufficiently large numbers, the plant becomes so weak that it is readily broken over and dies, without much secondary spread of the organism. This usually takes place at a time when the plant has developed to considerable size.

### CONTROL

The methods of control recommended for anthracnose are largely applicable to bacterial blight. Treating diseased seed with chemicals has thus far met with but little success. Since the organism is carried beneath the seed coat, it is extremely difficult to kill it without injuring the seed itself.

Since blight may live over in the soil, it is unwise to plant beans on the same ground for more than one year, especially if the previous crop was diseased. Lima beans, soybeans, cowpeas, and similar legumes should not be used in the rotation, because they also may be hosts of the bean-blight organisms.

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There are no bean varieties that are immune to bacterial blight, although not all varieties are equally susceptible to the disease, a few exhibiting a high degree of resistance. Table 1 shows the relative susceptibility and resistance to bacterial blight of some of the more common varieties of garden and field beans.

TABLE 1.—*Bean varieties grouped according to relative resistance and susceptibility to bacterial blight*

| Type and variety | Class | Kind of pod |
|---|---|---|
| **FAIRLY RESISTANT** | | |
| Dwarf: | | |
| Late Stringless Green Refugee | Garden | Green. |
| Refugee 1000-1 | do | Do. |
| Refugee Wax | do | Wax. |
| White Imperial | Field | Green. |
| Pole: | | |
| London Horticultural | Garden | Do. |
| Worcester Mammoth | do | Do. |
| **MODERATELY SUSCEPTIBLE** | | |
| Dwarf: | | |
| Blue Pod Small White | Field | Green. |
| Burpee Brittle Wax | Garden | Wax. |
| Burpee Stringless Green Pod | do | Green. |
| Burpee White Seeded Wax | do | Wax. |
| Early Wonder | Field | Do. |
| Extra Early Refugee | Garden | Green. |
| French Horticultural | do | Do. |
| Great Northern | Field | Do. |
| Giant Stringless Green Pod | Garden | Do. |
| Improved Kidney Wax | do | Wax. |
| Improved Black Wax | do | Do. |
| Keeney Rustless Wax | do | Do. |
| Robust | Field | Green. |
| Round Pod Kidney Wax | Garden | Wax. |
| Unrivaled Wax | do | Do. |
| Pole: | | |
| Creaseback | do | Green. |
| Cutshort | do | Do. |
| Golden Cluster Wax | do | Wax. |
| Kentucky Wonder Wax | do | Do. |
| Lazy Wife | do | Green. |
| McCaslan Pole | do | Do. |
| **VERY SUSCEPTIBLE** | | |
| Dwarf: | | |
| Boston Pea | Field | Green. |
| Bountiful | Garden | Do. |
| Black Valentine | do | Do. |
| Blue Pod Navy | Field | Do. |
| Currie Rust Proof Wax | Garden | Wax. |
| Davis White Wax | do | Do. |
| Dwarf Horticultural | do | Green. |
| Dwarf White Navy | Field | Do. |
| Early Navy | do | Do. |
| Full Measure | Garden | Do. |
| Hodson Wax | do | Wax. |
| Improved Golden Wax | do | Do. |
| Improved Navy | Field | Green |
| Low Champion Bush | Garden | Do. |
| Navy Pea | Field | Do. |
| Pea Bean | do | Do. |
| Pencil Pod Black Wax | Garden | Wax. |
| Pilot Navy | Field | Green. |
| Red Kidney | do | Do. |
| Red Valentine | Garden | Do. |
| Small White Navy | Field | Do. |
| Sure Crop Wax | Garden | Wax. |
| Tennessee Green Pod | do | Green. |
| Wardwell Wax | do | Wax. |
| White Navy | Field | Green. |
| White Kidney | do | Do. |
| Pole: | | |
| Case Knife | do | Do. |
| Kentucky Wonder | Field and garden | Do. |

The use of clean seed is probably the most important recommendation that can be made for the control of bacterial blight. When such seed is planted, the amount of secondary spread of blight will be appreciably reduced, since the centers of infection will have been eliminated. Disease-free seed can be grown with certainty only in localities where blight does not develop because of unfavorable climatic conditions. While blight does not occur every year in regions where it is frequently found, there is no way of predicting when it will occur. For this reason it is best not to attempt to grow seed in regions subject to yearly epidemics of blight.

Blight occurs in varying amounts each year in all States east of the Rocky Mountains. In the intermountain region it may be present, but does not appear regularly, and when it does occur is usually less severe than in the Eastern States. Furthermore, in certain Western States (Idaho and California for example) it does not occur in amounts large enough to be of any concern; hence, seed produced in these regions is relatively free from disease and should produce a crop relatively free from blight.

Since all western-grown bean seed is not blight-free every year, it is desirable to determine the exact location in which the seed was grown. Purchasers of large quantities who desire only blight-free seed should ascertain the condition of the crop in the region where the seed originated. This is the only method by which they can be sure whether the seed is free from blight.

## MOSAIC (CURLY LEAF)

### DESCRIPTION

Bean mosaic, sometimes known as curly leaf, has been known for a long time, but not until recent years has it become widespread and destructive. It rarely kills bean plants, and slight infections do not produce conspicuous symptoms. This fact may explain why it is frequently overlooked by growers.

Bean mosaic, like the mosaic diseases of many other crops, stunts the plant and causes mottling and various types of leaf malformation. The symptoms differ slightly with the variety, age of plants, and somewhat with the conditions under which the plants are grown. Leaves affected with mosaic usually have irregularly shaped light-yellow and green areas (fig. 5) of various sizes, a type of mottling characteristic of mosaic in general. This may be the only evidence of the disease. In addition to the characteristic mottling, however, there may be considerable puckering, malformation, and other alterations in the shape of the leaf. Mosaic-affected bean leaves may be narrower and longer than normal leaves, with considerable downward cupping of the leaf due to the unequal growth of the leaf tissues. Bean plants attacked early in the season are usually yellowish in color, often dwarfed and spindling, and fail to produce a normal crop. Plants affected late in the season may produce almost a normal crop. The symptoms of the disease can not be recognized on the stems, pods, or seeds.

### CAUSE

Bean mosaic is caused by a virus within the plant, the nature of which is not understood. If the leaves of a mosaic-affected plant

are briskly rubbed against the leaves of a healthy plant so that the plant juices intermingle, mosaic symptoms will develop in the inoculated plant in from 7 to 15 days. It becomes yellowed and stunted and eventually exhibits all the symptoms of the plant from which

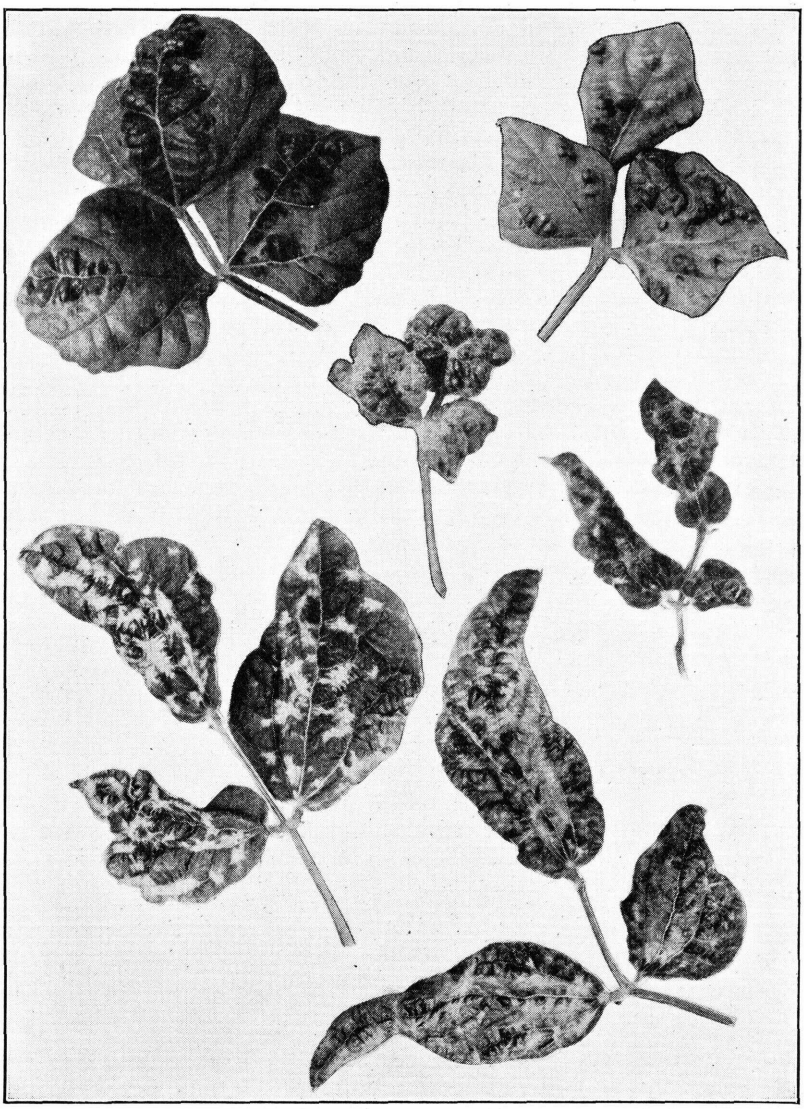

FIGURE 5.—Mosaic. Note the malformation of the leaves and the variation in their color. Mosaic is a seed-borne disease, and seed of affected plants should not be planted

the virus was taken. The mosaic-infected plant juice or virus may be carried throughout the entire plant and cause the seed to become infected, without producing any symptoms on the pod or seed. When planted, such seed, although appearing normal in all respects, may produce diseased plants. Not all the seeds of a mosaic-infected

plant carry the virus, but enough are infected to cause a considerable percentage of mosaic in the progeny. Some of the plants produced from such seeds are so stunted that they fail to develop to maturity. Others, slightly infected, may mature but produce diseased seed.

Under certain weather conditions the disease may not manifest itself even though the virus is in the plant. Because of this fact it is often difficult to diagnose the condition of certain infected plants. The same plants placed under different environment will exhibit decided mosaic symptoms. Infection is favored by reasonably high temperatures, while low temperatures tend to mask the symptoms.

### CONTROL

No known treatment of the seed or plants is effective in controlling mosaic. The virus is so intimately associated with the seed itself that all attempts to kill it have also destroyed the seed. Inasmuch as the causal agency is carried in the seed, the use of disease-free seed and resistant varieties is recommended.

There are no varieties that show absolute immunity to mosaic. The best method of preventing the disease is by the introduction of seed stock from regions reasonably free from the malady. Because of the widespread distribution of the disease, it is somewhat improbable that seed absolutely mosaic free can be procured, although comparatively clean seed is produced along the Pacific coast. It is not good policy for growers to plant seed of unknown origin. It is advisable, in case of slight infection, to rogue out all suspicious plants as soon as they are seen, thereby reducing the chances of secondary spread.

Certain varieties of beans that show decided resistance to the disease may be grown where mosaic is very prevalent. While not entirely immune, they are infected so slightly that the disease does not cause an appreciable stunting of the plant or reduction in yield. Table 2 shows the relative susceptibility and resistance to mosaic of different varieties.

TABLE 2.—*Bean varieties grouped according to relative resistance and susceptibility to mosaic*

FAIRLY RESISTANT

| Type and variety | Class | Kind of pod |
|---|---|---|
| Dwarf: | | |
| Black Valentine | Garden | Green. |
| Bountiful | do | Do. |
| Burpee Brittle Wax | do | Wax. |
| Burpee Stringless Green Pod | do | Green. |
| Davis White Wax | do | Wax. |
| Dwarf White Navy | Field | Green. |
| Full Measure | Garden | Do. |
| Giant Stringless Green Pod | do | Do. |
| Improved Kidney Wax | do | Wax. |
| Pinto | Field | Green. |
| Robust | do | Do. |
| Round Pod Kidney Wax | Garden | Wax. |
| Unrivaled Wax | do | Do. |
| Pole: | | |
| Creaseback | do | Green. |
| Kentucky Wonder | do | Do. |
| Kentucky Wonder Wax | do | Wax. |
| McCaslan Pole | do | Green |

TABLE 2.—*Bean varieties grouped according to relative resistance and susceptibility to mosaic*—Continued

MODERATELY SUSCEPTIBLE

| | | |
|---|---|---|
| Dwarf: | | |
| Blue Pod Small White | Field | Green. |
| California Red | do | Do. |
| California Pink | do | Do. |
| Currie Rust Proof Wax | Garden | Wax. |
| Dwarf Horticultural | do | Green. |
| Extra Early Refugee | do | Do. |
| French Horticultural | do | Do. |
| Genuine Small White | Field | Do. |
| Improved Black Wax | Garden | Wax. |
| Improved Golden Wax | do | Do. |
| Keeney Rustless Wax | do | Do. |
| Low Champion Bush | do | Green. |
| Pencil Pod Black Wax | do | Wax. |
| Red Kidney | Field | Green. |
| Sure Crop Wax | Garden | Wax. |
| Tennessee Green Pod | do | Green. |
| Wardwell Wax | do | Wax. |
| White Kidney | Field | Green. |

VERY SUSCEPTIBLE

| | | |
|---|---|---|
| Dwarf: | | |
| Blue Pod Navy | Field | Green. |
| Boston Pea | do | Do. |
| Burpee White Seeded Wax | Garden | Wax. |
| Early Navy | Field | Green. |
| Early Wonder | do | Do. |
| Great Northern | do | Do. |
| Hodson Wax | Garden | Wax. |
| Improved Navy | Field | Green. |
| Late Stringless Green Refugee | Garden | Do. |
| Navy Pea | Field | Do. |
| Pea Bean | do | Do. |
| Pilot Navy | do | Do. |
| Red Valentine | Garden | Do. |
| Refugee 1000-1 | do | Do. |
| Refugee Wax | do | Wax. |
| Small White Navy | Field | Green. |
| White Imperial | do | Do. |
| White Navy | do | Do. |
| Pole: | | |
| Cutshort | Garden | Do. |
| Golden Cluster Wax | do | Wax. |
| Lazy Wife | do | Green. |
| London Horticultural | do | Do. |
| Worcester Mammoth | do | Do. |

## RUST

### DESCRIPTION

Rust of beans may occur on any aerial part of the plant, but is found most abundantly on the leaves. (Fig. 6.) Large unsightly pustules are sometimes found on the pods, petioles, and the tender parts of the stem. During the summer the pustules are reddish brown, circular, often with a secondary ring, and frequently surrounded by a zone of tissues yellowed by the loss of the green coloring matter. On the pods, petioles, and stems the lesions are large, more or less irregular in shape, and noticeably raised.

### CAUSE

Bean rust is caused by a fungus (*Uromyces phaseoli typica* Arthur). Like similar organisms, it is propagated by means of spores. There are several stages in the development of this rust, but only two need be considered here. The red-rust stage occurs in the summer and is most important in the current season's distribution of the disease. These spores may germinate and cause infection as soon as they are mature. In a few weeks they are

replaced by another type of spore with thick walls, which is capable of surviving the severe weather of winter. In the spring these winter spores germinate and under proper conditions for their spread and development they may cause infection, thus completing the life cycle of the fungus.

The occurrence and distribution of bean rust are closely correlated with atmospheric conditions. Rust is likely to occur in regions where cool nights and high humidities prevail. That is why the

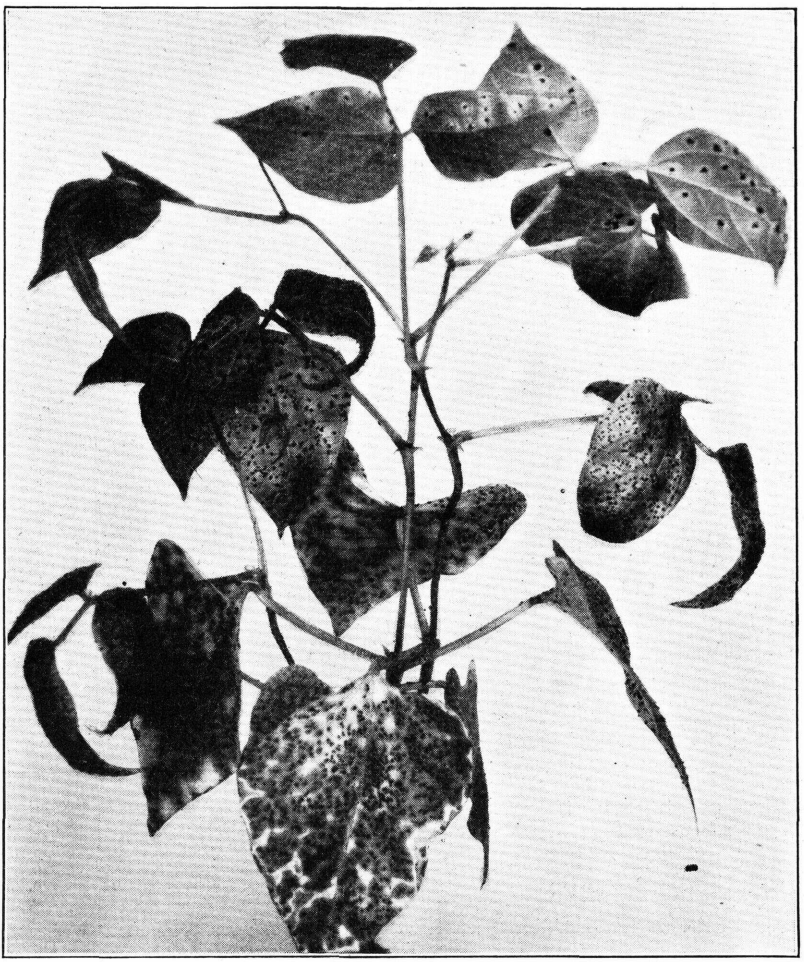

FIGURE 6.—Bean rust. This disease is very destructive to susceptible varieties during seasons favorable for its development. The pustules may develop on the leaves in numbers sufficient to defoliate the plants. Rust is not seed borne

disease often occurs only in the latter part of the season, or in the fall. On the other hand, occasional epidemics in some of the western bean-growing regions (Colorado, for example) during the summer have been so severe that the entire crop was wiped out. Such epidemics, though occurring only rarely, can be definitely associated with weather conditions, such as cool nights accompanied by a period of damp, rainy weather, favorable to the disease.

CONTROL

No treatment of seed or plants is effective in controlling bean rust. The use of resistant varieties can be recommended. Unfortunately, a few of the best garden varieties and many of the dry-shelled or field varieties are very susceptible. Table 3 gives a partial list of the varieties that show a degree of resistance sufficient to justify their being planted in localities where the disease is a limiting factor. The table shows that there is considerable choice of resistant varieties in the garden group, while most of the field varieties are very susceptible, those showing some degree of resistance not being the ones most widely grown.

TABLE 3.—*Bean varieties grouped according to relative resistance and susceptibility to rust*

| Type and variety | Class | Kind of pod |
|---|---|---|
| **FAIRLY RESISTANT** | | |
| Dwarf: | | |
| Black Valentine | Garden | Green. |
| Bountiful | do | Do. |
| Burpee Brittle Wax | do | Wax. |
| Burpee Stringless Green Pod | do | Green. |
| Burpee White Seeded Wax | do | Wax. |
| Currie Rust Proof Wax | do | Do. |
| Cranberry | Field | Green. |
| Extra Early Refugee | Garden | Do. |
| Fordhook Favorite Bush | do | Do. |
| French Horticultural | do | Do. |
| Full Measure | do | Do. |
| Giant Stringless Green Pod | do | Do. |
| Hodson Wax | do | Wax. |
| Improved Kidney Wax | do | Do. |
| Improved Golden Wax | do | Do. |
| Improved Black Wax | do | Do. |
| Keeney Rustless Wax | do | Do. |
| Late Stringless Green Refugee | do | Green |
| Low Champion Bush | do | Do. |
| Pencil Pod Black Wax | do | Wax. |
| Refugee 1000-1 | do | Green. |
| Refugee Wax | do | Wax. |
| Round Pod Kidney Wax | do | Do. |
| Rust Proof Golden Wax | do | Do. |
| Sure Crop Wax | do | Do. |
| Wardwell Wax | do | Do. |
| Pole: | | |
| King Mammoth Horticultural | do | Green. |
| Lazy Wife | do | Do. |
| **MODERATELY SUSCEPTIBLE** | | |
| Dwarf: | | |
| Bayo | Field | Green. |
| Canadian Wonder | Garden | Do. |
| Large White Marrow | Field | Do. |
| Longfellow | Garden | Do. |
| Red Kidney | Field | Do. |
| Red Valentine | Garden | Do. |
| White Kidney | Field | Do. |
| Pole: | | |
| Golden Cluster Wax | Garden | Wax. |
| Kentucky Wonder Wax | do | Do. |
| **VERY SUSCEPTIBLE** | | |
| Dwarf: | | |
| Blue Pod Small White | Field | Green. |
| California Pink | do | Do. |
| California Red | do | Do. |
| Genuine Small White | do | Do. |
| Great Northern | do | Do. |
| Large White | do | Do. |
| Pea Bean | do | Do. |
| Pinto | do | Do. |

TABLE 3.—*Bean varieties grouped according to relative resistance and susceptibility to rust*—Continued

VERY SUSCEPTIBLE—Continued

| Type and variety | Class | Kind of pod |
|---|---|---|
| Dwarf—Continued. | | |
| Red Mexican | Field | Green. |
| Robust | do | Do. |
| Tennessee Green Pod | Garden | Do. |
| Pole: | | |
| Case Knife | do | Do. |
| Creaseback | do | Do. |
| Kentucky Wonder | do | Do. |
| Kentucky Wonder Wax | do | Wax. |
| McCaslan Pole | do | Green. |

## ROOT ROTS

### DESCRIPTION AND CAUSES

A number of different organisms may cause root rots of beans. Unfortunately, the symptoms caused by some of them are so similar that it is sometimes impossible to distinguish among them. Root rots occur more or less extensively wherever beans are grown, but on the whole a larger number of root parasites occur and cause more damage to the crop in the Southern States. The diseases of the roots are, for the most part, caused by organisms that live in the soil on decomposed vegetable matter, but which are capable of attacking beans as well as a large number of other crops when soil and other conditions become unfavorable for the best plant growth.

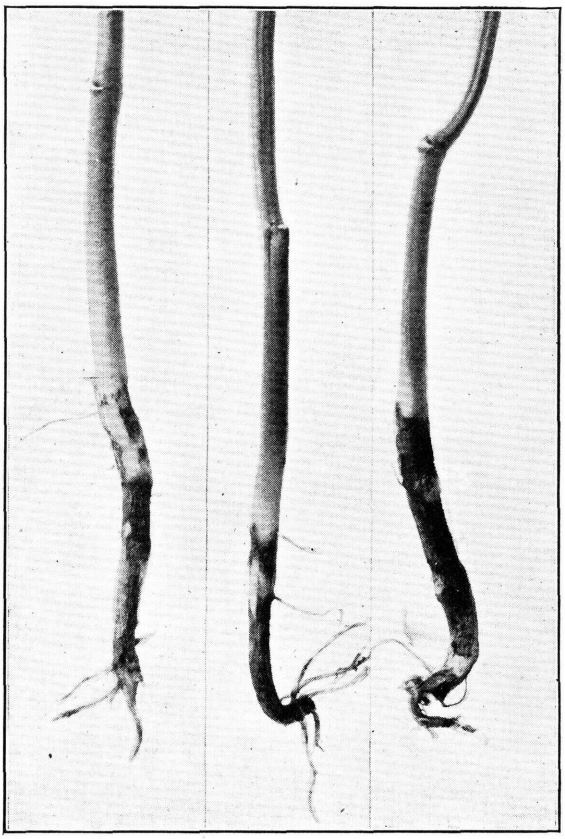

FIGURE 7.—Root rots, a group of diseases caused by several different fungi that inhabit the soil. They destroy the feeding roots and cause cankers on the stem at or below the level of the soil

Root rots, as a group, are characterized by the formation of cankers and lesions on the stem below the soil level (fig. 7) and on the small fibrous rootlets. These cankers and lesions may be of various sizes and may be gray, brown, black, or even bright red. The tips of the fibrous roots are frequently decayed for some distance from the end.

CONTROL

No effective control for the various root rots is known. However, the employment of certain cultural practices which can always be recommended will considerably lessen the severity of the disease.

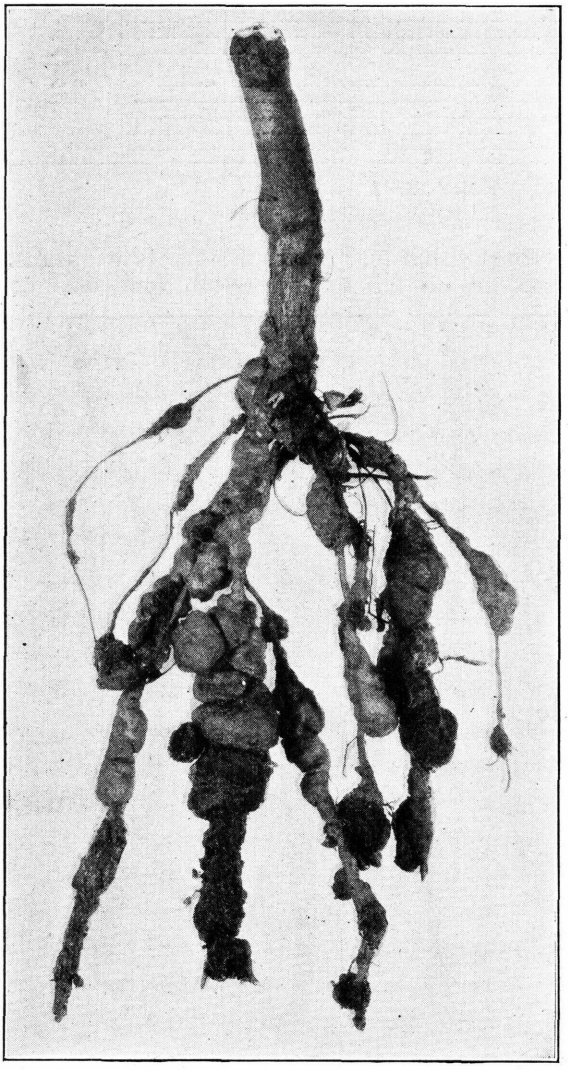

FIGURE 8.—Root knot. This disease is caused by a small parasitic eelworm or nematode which invades the roots. Note the galls formed at various places. Root-knot invasion retards the growth, reduces the yield, and often kills the plants

A rotation of at least two to three years is essential, the cropping system to include cereals (corn, oats, and others), clover, and alfalfa, plants on which the bean root-rotting organisms are rarely if ever found to produce any lasting damage.

Among the principal root rots, that produced by Rhizoctonia (well known on potatoes) is the one most frequently encountered. Fortunately, this organism is not an aggressive parasite under conditions conducive to strong, vigorously growing bean plants.

The organisms responsible for root rots seem to thrive best under conditions not ideal for the bean crop. Therefore, any measures that improve the general growing conditions of the beans will help to reduce the severity of root rots.

Since root-rot organisms are normal inhabitants of practically all soils, they can not be entirely eliminated. All that can be done is to make conditions so favorable for the bean plant that it will thrive in spite of the potential parasites in the soil.

## ROOT KNOT

### DESCRIPTION

Root knot, largely confined to the light sandy soils of the South and to similar regions in California, is characterized by enlarged, irregularly shaped, deformed fleshy galls (fig. 8) distributed on the bean root system. If the galls are broken open, pearl-white bodies about the size of a pinhead may often be seen. These are the female worms that cause the galls.

Occasionally the root-knot galls may be confused with the nodules that normally develop on the roots of garden and field beans, Lima beans, and other legumes. Careful comparison shows the two to be quite different. The nodules are usually smaller than the root-knot galls, more nearly round, and are attached somewhat loosely to the sides of the roots, whereas the root-knot galls are enlargements of the roots themselves. The bacteria that form the nodules change the nitrogen of the air into forms that are of some benefit to the plant and that are later changed into nitrates in the soil and thus become available to subsequent crops. Plants bearing nodules generally grow well and look healthy. On the other hand, plants with root knot are usually stunted, yellow, and sickly looking and may even be killed by the disease.

### CAUSE

Root knot is caused by a parasitic eelworm, or nematode (*Heterodera marioni* (Cornu) Goodey), so small as to be almost invisible to the naked eye. It enters the small roots and causes them to form the irregular swellings or galls characteristic of the disease. To a considerable extent these galls cut off the transport of food material from the roots to the rest of the plant. These little eelworms migrate very slowly in the soil, probably not covering more than 1 to 2 yards in a year. They overwinter in the soil.

### CONTROL

The eelworms, or nemas as they are generally called, are parasitic on a large number of cultivated plants and on many weeds. However, a number of crops are practically immune to their attack. Among the latter may be mentioned the Iron, Brabham, Victor, and Monetta cowpeas, the Laredo soybean, velvetbeans, corn, barley, rye, redtop, sorghum, timothy, wheat, and winter oats.

The most satisfactory method of controlling the disease is to practice rotation with immune crops for three or more years, or to allow the land to lie fallow for three years in order to starve out the nemas. Clean cultivation should be practiced to prevent the growth of susceptible weeds on which the nemas could feed. The nemas may be transported from one field to another or over long distances in the tubers, bulbs, and roots of growing plants; by implements and drainage water; by farm animals allowed to roam from one field to another; and probably by other means. Distribution of the nemas by any of these means should be prevented as far as possible.

## CURLY TOP

### DESCRIPTION

Curly top of beans was first reported in 1924, from southern Idaho. In certain stages of development its symptoms resemble those of bean mosaic, although in the later stages they are quite distinct. Plants affected with curly top are decidedly dwarfed. Young plants show the most pronounced symptoms on the trifoliolate leaves, which pucker and curl downward, and show a clearing of the leaf veins. (Fig. 9.) On some varieties the young leaves are decidedly dwarfed

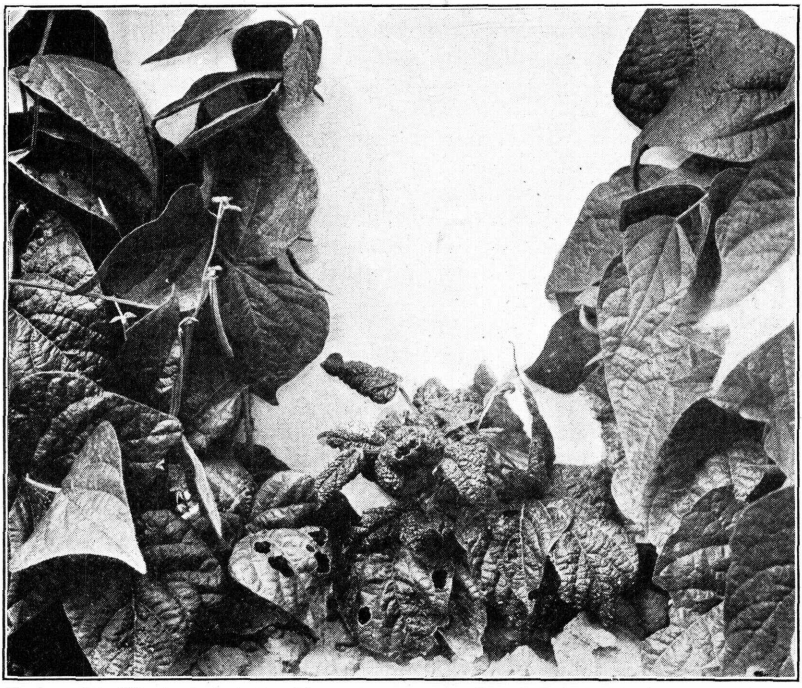

FIGURE 9.—Plants infected with curly top are dwarfed and the leaves yellowed, puckered, and curled. Note healthy plants on either side of the diseased one. Curly top is spread by a small leaf hopper. The crop is sometimes completely destroyed. The disease occurs only in some of the Western States

and darker green than normal. Cupping of the leaves sometimes continues until each leaf resembles a small green ball. The young leaves frequently cease to develop, turn yellow, and curl downward. Such leaves are thicker than normal and very brittle, readily breaking off from the main stem. A plant thus affected generally dies before the pods develop.

Plants infected late in the season do not always develop typical symptoms of the disease, and generally grow to maturity. The pods that are produced are often stunted, this being one of the symptoms. The disease is not seed borne.

### CAUSE

The cause of curly top, like that of mosaic, is undetermined. The disease is spread from plant to plant by a leaf hopper (*Eutettix*

*tenellus* Baker), frequently referred to in some western sections as the " white fly." Before infecting a bean plant the leaf hopper must have fed on some curly-top infected plant, either bean, beet, tomato, or one of many other hosts susceptible to the disease. The symptoms appear about 10 days to 2 weeks after infection. If severely infected the plant may die within a few weeks after the first appearance of symptoms.

Since the disease is not transmitted except by the leaf hopper, curly top is prevalent only where that insect thrives, viz in Idaho, Utah, Oregon, Washington, California, New Mexico, and parts of Colorado and Wyoming. The severity of the disease in these States is dependent on the leaf-hopper population, which varies from season to season.

#### CONTROL

No control measures for curly top have been developed. The only variety of beans known to be resistant to curly top is the Red Mexican, a field type. In regions where leaf hoppers are abundant this variety resists the disease and produces a normal crop. Since curly top is not seed borne, seed originating where the disease is prevalent may safely be planted in any section of the country.

### BALDHEAD (SNAKEHEAD)

#### DESCRIPTION

An examination of bean fields soon after the seedlings emerge from the ground often reveals a considerable percentage of the young plants with no growing tips. (Fig. 10.) The stem above the cotyledons, which in normal plants would develop further growth, is broken off, leaving only a bare stump. Sometimes this stump will grow for a short time and extend an inch or more above the cotyledons. Occasionally the plant dies without making much more growth, but usually new shoots are developed in the axils of the cotyledons, and a few flowers and pods may be produced. However, the plant always remains small and is generally smothered and crowded out by more vigorous neighboring plants. This abnormality is known as baldhead or snakehead.

#### CAUSE

Baldhead is known to be caused in three different ways: (1) By injury of the embryo in threshing, (2) by insects, and (3) by bacteria and fungi. More baldhead is caused by the threshing machine than by any other agency. The drier the seed and the greater the speed of the cylinders in the threshing machine, the greater the damage is likely to be. As much as 20 to 30 per cent of the seed of some varieties may be damaged in this way.

During some seasons the seed-corn maggot causes considerable damage to the terminal bud, either before or at the time the seedling is emerging from the soil. The maggot, eating into the growing bud or eating it off the plant, produces an injury somewhat resembling that caused by the threshing machine. The plant rarely recovers from this condition.

Bacterial organisms which harbor beneath the seed coats also cause baldhead. As the seed germinates, these organisms attack the growing bud of the young plant and partially or completely destroy it so that it is unable to grow into a productive plant. Baldhead caused by bacteria will not occur in seed that is free of blight.

#### CONTROL

There is no remedy for baldhead. The grower should refuse to accept seed of which a high percentage is cracked. Such seed, if planted, will produce a considerable number of baldhead plants.

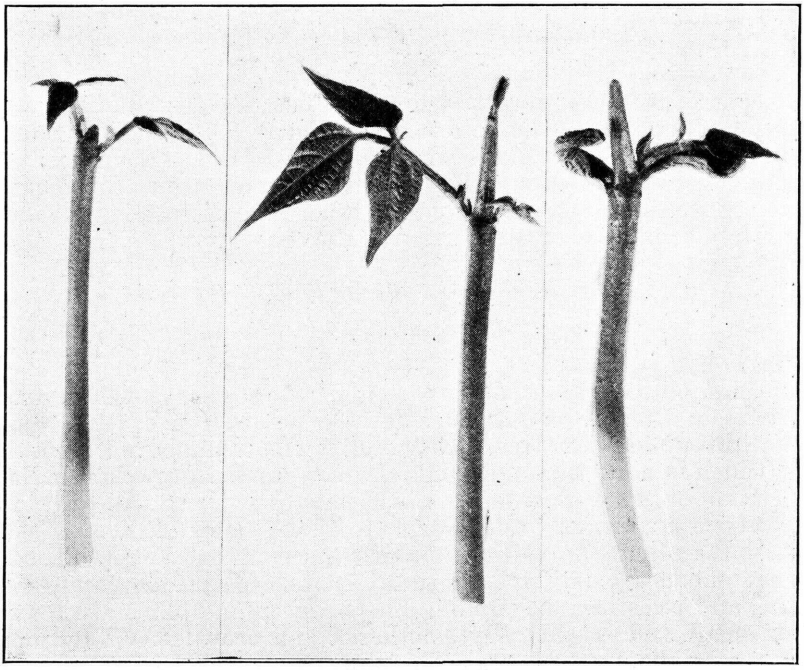

FIGURE 10.—Baldhead. The embryonic plant in the seed is damaged when the beans are threshed, so that growth is impossible. The injury is done by the seed being hurled against the teeth of the cylinders and concaves of the threshing machine. Similar injury to the terminal bud is sometimes caused by insects, bacteria, and fungi

Control of baldhead caused by the threshing machine rests wholly in the hands of those who thresh the seed. A reduction in the speed of the cylinders probably would reduce the loss. The use of rubber shields on the teeth of the cylinders and concaves or the substitution of some substance not so hard as the iron teeth would also be helpful.

The use of disease-free seed will eliminate baldhead caused by bacteria and fungi.

### POWDERY MILDEW

#### DESCRIPTION

Powdery mildew is widely distributed, having been reported or observed in almost all parts of the United States. It is more abundant in the Southern States and along the Pacific coast than else-

where and usually causes the most damage to crops maturing late in the fall and those produced in the extreme South during the winter.

Powdery mildew is characterized by the production of a white talc-like substance on all parts of the plant aboveground. (Fig. 11.) The leaves turn yellow, cup downward, and, in the case of severe attacks, fall off. The pods are often malformed, small, poorly filled, and frequently fall off without bearing any seed. The pods and stems are oftentimes purplish in color.

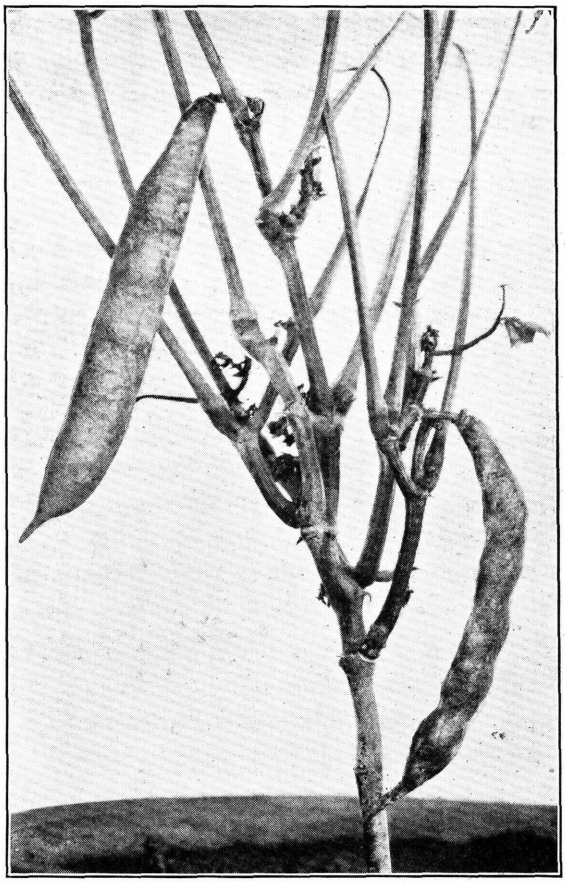

FIGURE 11.—Powdery mildew, a disease characterized by a white, powdery, dustlike covering on the leaves and other aboveground parts of the plant. It is here shown on the pods and stem

#### CAUSE

Powdery mildew is caused by a fungus (*Erysiphe polygoni* DC.) which is parasitic on more than 300 other host plants. The spores, produced in great numbers on the leaves, pods, and stems, are easily dislodged and carried by the wind and other agencies from one plant to another. Powdery mildew develops so rapidly that an entire crop may be badly damaged with in a few days.

#### CONTROL

Powdery mildew may be held in check by one or two dustings with powdered sulphur. The first application should be made as soon as there is any evidence of the disease. The second should follow within a week or 10 days.

### ASHY STEM BLIGHT

#### DESCRIPTION

Ashy stem blight infections begin at or below the level of the soil and extend down the stem into the roots and upward, often some distance, into the branches. The lesions on young plants are somewhat sunken and reddish brown in color and differ from those on older stems in that the latter are usually little or not at all sunken. As

the lesions enlarge they turn gray at the center, in which are found numerous black fruiting bodies about the size of a pin point. These fruiting bodies stand out in sharp contrast against the ashy gray background. Since the plants usually become infected when quite young, they are generally killed before they produce seed.

The losses from ashy stem blight are sometimes very large. In Mississippi as much as 65 per cent of the crop has been destroyed, the amount of loss depending to a considerable extent on weather conditions. It is highest during seasons with considerable rainfall, and is often entirely absent in dry seasons. Considerable loss has also been reported from South Carolina, North Carolina, and other Southern States.

The ashy stem blight organism attacks Lima beans as well as garden beans. It is distributed quite generally in the Southern States, along the Atlantic seaboard, and in California.

### CAUSE

Ashy stem blight is caused by a fungus (*Macrophoma phaseoli* Maubl.). Numerous spores are produced in the black fruiting bodies on the stems. The indications are that the organism survives from one season to the next on plants left in the field from a former crop.

### CONTROL

No control for ashy stem blight has been developed. It is not unlikely that a rotation with crops other than beans, Lima beans, and sweetpotatoes for two or three years would be helpful.

### SUN SCALD

Sun scald usually occurs near the end of the growing season when the beans are reaching maturity. The lesions, most conspicuous on the pods, appear first as tiny brown or reddish spots on that part of the plant exposed to the sun. The spots enlarge and later appear as short streaks or markings extending diagonally between the sutures of the pod. These discolorations may easily be mistaken for early bacterial-blight infections and in some cases can not be properly diagnosed except with a microscope. In the later stages, however, there is little difficulty in distinguishing these lesions, since a dried, scaly, white or yellow, slimy mass is associated with bacterial-blight infections, whereas no exudate is present with sun scald.

These small spots or streaks increase in size and sometimes form slightly sunken brown areas. If rapid spread occurs the lesion may extend over most of the pod that is exposed to the sun. This spotting may eventually appear on the opposite side of the pod, but is never as serious as on the surface exposed to the sun. Sometimes the markings are noted on the stems and petioles of the plant as brownish-red streaks and are seen only on that side of the plant exposed to the sun.

No appreciable loss is caused by sun scald. Occasionally, when pod spotting is severe, the seeds will be slightly discolored, giving the appearance of bacterial infection. Such seed is often difficult to detect, especially with dark-seeded varieties. The germination of seed so discolored is in no way affected and normal plants are produced.

The discoloration of the pods and stems is a result of exposure to the direct rays of the sun and is in no way associated with any organism, and it does not occur when the plant parts are shaded. No practical control for sun scald is known.

### ANGULAR LEAF SPOT

Angular leaf spot of beans, caused by a fungus (*Isariopsis griseola* Sacc.), occurs occasionally in the Eastern States and is found mostly on the underside of the leaves and sometimes on the pods. On the leaves it causes small angular spots which may be numerous enough to cause some defoliation. The spots are brown at first, but, when the fungus fruits, the surface of the lesions becomes more or less gray. The spots on the pods are usually small, although they may sometimes be large and noticeable. They are conspicuous because they are black with brown or red centers.

Angular leaf spot is rarely severe or common enough to require remedial measures, and none are recommended.

## DISEASES OF LIMA BEANS

### DOWNY MILDEW

#### DESCRIPTION

Downy mildew of Lima beans can be recognized by the white, cottony growth which forms in large patches on the pods. (Fig. 12.) It sometimes occurs on the tender shoots and flower parts and occasionally on the leaves. The young branches are distorted, but a profuse fungous growth, such as is found on the pods, does not occur on them. A purplish border separates the dense cottony growth on the pod from the healthy tissue. The fungous threads grow through the pods and into the seed, where the organism may live through the winter. Such seed, if planted, may be a source of the

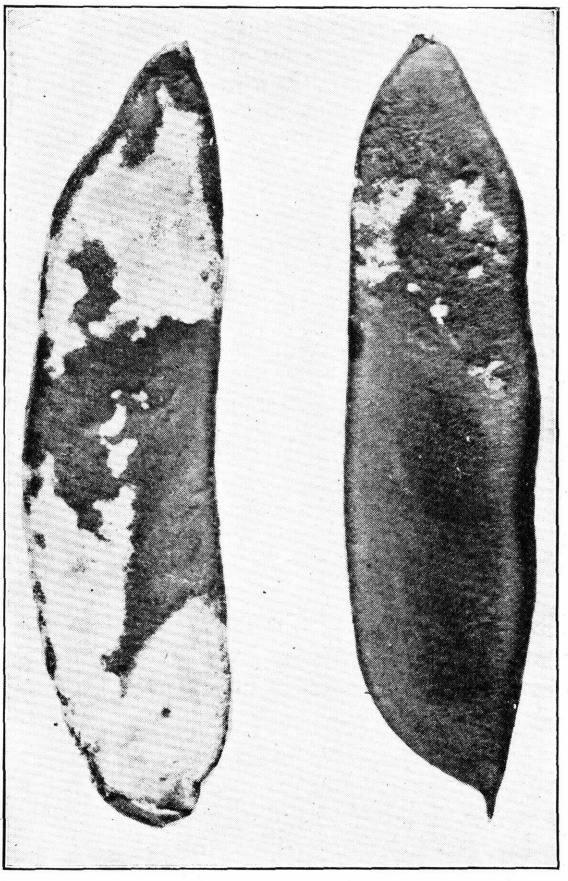

FIGURE 12.—Downy mildew, a white, cottony, fungous growth on the pods of Lima beans. Damp, rainy weather is favorable for its development

disease the next year. If the pods become diseased while quite young they usually wither and die without producing seed.

Downy mildew may cause heavy damage during seasons favorable for the development of the fungus. It is favored by wet weather, cool nights, heavy dews, and fairly warm days. The disease is most prevalent along the Atlantic seaboard, but has been reported inland and from California. It is spread by winds, rains, pickers, and probably by insects and other means.

#### CAUSE

Downy mildew is caused by a fungus (*Phytophthora phaseoli* Thax.) and occurs only on Lima beans. It may live from one season to the next in two or three ways. The causal fungus penetrates the seed and lives in it throughout the winter. It also survives the winter in dead vines and pods in the field. Both the seed and the débris are sources of infection of the new crop.

#### CONTROL

Inasmuch as the fungus causing downy mildew is carried by the seed, only clean seed should be planted. Where this disease occurs it is never advisable to save seed for the next crop. It is far better to obtain seed grown in the West, as, for example, Colorado and California, where downy mildew rarely occurs. Collecting and burning dead vines and pods in the fall after the crop is harvested help to control the disease. A crop rotation of two to three years should be practiced if possible. Spraying the vines with a 4-4-50 Bordeaux mixture has been recommended, but to be effective such spraying should be started before the disease becomes established. Since downy mildew does not occur regularly every year, and usually not more than once in every three or four years, it is impossible to foretell when a fungicide should be applied. If Bordeaux is used, it should be applied each year before the disease occurs. It is doubtful whether this would be a profitable procedure, since Bordeaux is liable to be deposited on the pods and might thus affect their market value.

### POD BLIGHT

#### DESCRIPTION

Pod blight is more prevalent on the pole varieties than on the bush varieties of Lima beans. It has been reported from most of the States along the Atlantic seaboard and from Ohio and West Virginia, and it probably occurs elsewhere. During seasons favorable to the disease it causes considerable damage to the commercial crop. The disease appears first on the leaves as brown irregularly shaped patches which vary in size with age and often attain a diameter of one-fourth to three-fourths of an inch. During the latter part of the growing season the causal fungus spreads to the pods, causing pale, somewhat watery-looking spots. These spots (fig. 13) slowly enlarge and gradually darken. In these spots greenish-gray pimples about the size of a pinhead, arranged roughly in circles, develop. When these pimples break through the skin of the pod they turn dark brown to

nearly black. They are the bodies in which the spores of the fungus are borne. They rarely occur on the stem of the living plant, but are prevalent on the leaves before they are found on the pods.

### CAUSE

Pod blight is caused by a fungus (*Diaporthe phaseolorum* (Cke. and Ell.) Sacc.) which lives through the winter on dead vines and pods left in the field. It has also been found on the seed, but its presence there is not of any great economic importance, since most of the seed is grown along the Pacific coast, where the disease does not occur.

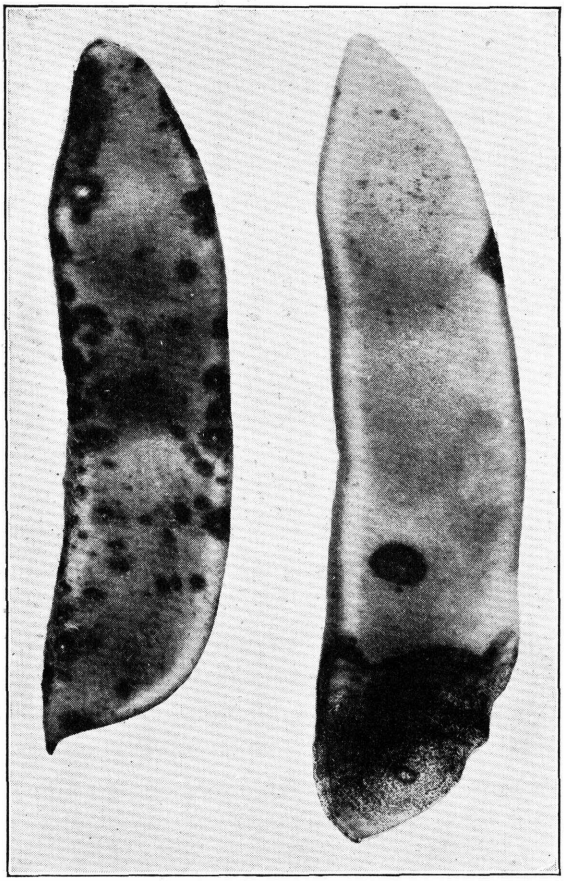

FIGURE 13.—Pod blight of Lima beans. It appears first on the leaves and later on the pods, where large, unsightly dead cankers are formed. Numerous spores of the fungus form in fruiting bodies in the cankers

### CONTROL

Little control has been attempted. Spraying the vines with a 4–4–50 Bordeaux mixture has been recommended but not generally practiced. If spraying is attempted it should be started when the plants are about 2 feet tall. Inasmuch as the causal organism is carried from one season to the next on dead vines and pods, they should be gathered up and burned as soon as the crop is harvested. No seed should be saved from fields in which pod blight has occurred. Seed grown in the West should be planted.

### BACTERIAL SPOT

Bacterial spot occurs on the leaves, stems, and pods of Lima beans. The lesions on the leaves are small, reddish brown, and irregular in shape and size. The dead plant cells at the center of the spots often dry and fall away, leaving small holes. Small spots or lesions are often found on the stems and pods.

The damage caused by this disease is rarely enough to require control measures, and none have been worked out. Crop rotation and the use of disease-free seed should be practiced.

The bacterial spot of Lima beans is caused by bacteria (*Bacterium vignae* Gardner and Kendrick) that are very similar to but not identical with the organism causing the blight of garden and field beans.

### YEAST SPOT

Yeast spot, a disease of the seed only, was discovered on Lima beans in Virginia and was later reported in Tennessee, Alabama, and Illinois. In 1930 the disease was prevalent on garden beans in the northwestern part of the United States, which indicates its wide distribution. It causes dark, irregularly shaped, sunken spots on the seed coat. (Fig. 14.) While the causal fungus (*Nematospora phaseoli* S. A. Wingard) is able to attack the seed at any time during

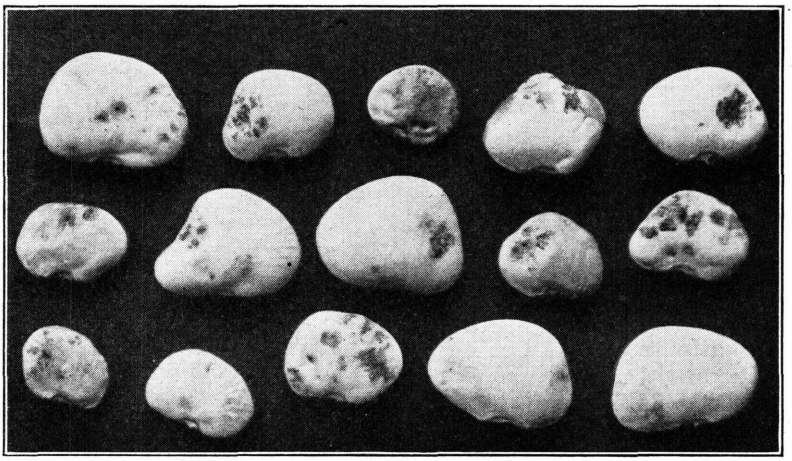

FIGURE 14.—Yeast spot, found mostly on Lima beans. Irregularly shaped cankers are produced on the seed by a yeast fungus which gains entrance through insect punctures of the pod

its growth, it is most destructive to young, immature seed. If attacked when very young, the seed will not mature, but instead dries up in the pod. Infection is apparently brought about by an insect which punctures the green succulent pod and the seed within it. Evidence of the yeast spot does not appear on the outside of the pod. The damaged condition of the seed can be seen only after splitting the pod open.

The infection of the seed is reported to range from a trace to as much as 90 per cent. Yeast spot has occurred on several different varieties of Lima beans, but the Sieva type appears to be especially susceptible. It has been reported on some varieties of garden beans

and cowpeas. Infection is slight during the early part of the growing season, but increases in severity as the plants near maturity.

No control measures have been developed. Any control would require the protection of the pods against being punctured by the insects that carry the causal agent.

### BALDHEAD (SNAKEHEAD)

Baldhead (snakehead) has been fully discussed under garden and field beans. The facts brought out apply also for Lima beans. (P. 19.)

### ASHY STEM BLIGHT

For discussion of ashy stem blight, see page 21.

### DISEASES OF GARDEN AND LIMA BEANS FOUND IN TRANSIT

The diseases of snap as well as Lima beans that are found in transit are further manifestations of field diseases. There is probably no malady of beans peculiar to transit conditions, all of them being referable to conditions in the field during harvest or before it.

Diseases appearing on the pods as somewhat definite spots show much the same characteristics in transit as in the field, any differences being attributable to the changes that would naturally occur in any fruit after being removed from the plant for some time. Ideal shipping conditions should include maximum aeration and a temperature and humidity that would reduce excessive drying out and at the same time prevent sweating.

Some diseases, like anthracnose and bacterial blight, will develop appreciably during four or five days in transit under high temperature and high humidity. While it has been proved that anthracnose will initiate new infections under transit conditions, bacterial blight apparently can only continue the development of infections already started.

Many of the root-rot fungi attack pods when they are in contact with the soil. Such infected pods, when shipped or held at the market under reasonably high temperature and humidity, may become centers of decay whose extent depends on the length of exposure to favorable conditions.

Inasmuch as transit diseases are directly correlated with field conditions, supplemented and aggravated by improper conditions of shipment, rigid application of control measures recommended for field diseases is of primary importance. After a crop has been raised in the best possible manner, it should be carefully graded and all beans showing blemishes and disease spots discarded. The beans should be picked when the vines are dry, and the filled hampers should be protected from the direct rays of the sun and kept from getting wet. When possible the beans should be precooled and shipped in iced cars; otherwise they should be shipped as quickly as possible and in hampers so packed as to allow the maximum aeration consistent with freedom from leakage and breakage.

What may happen in transit to garden beans is amply illustrated in figures 15 and 16. Figure 15 shows a hamper of beans taken from a carlot shipment just as it arrived on a northern market, seriously infected by the anthracnose fungus (p. 2). These beans were selected for freedom from disease and packed for shipment; although an-

FIGURE 15.—A hamper of garden beans from a carlot shipped from the South to a northern market, showing the damage caused by anthracnose.

thracnose was prevalent in the field, all infected pods were supposed to have been thrown out. Only a few days in transit were required to bring about the condition shown; the infections shown illustrate the impossibility of discovering all infected pods. Some are sure to get into the hampers and spread infection throughout. Control of the disease in the field by the use of disease-free seed is the only sure remedy for anthracnose.

Watery soft rot, caused by the fungus *Sclerotinia sclerotiorum*, is one of the worst of the transit and market diseases of beans. It is also a field disease. During the past few years, it has increased in the Southern States and has caused so much loss in the field that some farmers are tempted to discontinue the growing of beans altogether.

FIGURE 16.—Hampers of garden beans, part of a shipment from the South to a northern market, made worthless by the nesting of the watery soft rot fungus.

Infection of the pods takes place in the field. The graders are supposed to throw out the infected pods, but they overlook many that find their way into the hampers. The causal fungus grows rapidly at high humidity and in a few days spreads throughout a hamper and destroys the entire contents. Figure 16 shows the white growth of the causal fungus as it appeared in hampers of beans just after they had arrived on the market.

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